Agenda

HPC Industry and Market Trends

Driving the Change in HPC

HPC Building Blocks

HPC Solutions

Software Toolset

intel

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CAE Challenges

Shorten Design and Development Time

- Shorten time-to-market
- Reduce expensive and time consuming mechanical tests
- Reduce material (costs, weight, new)
- Optimize specific features, e.g.
  - Statics
  - Dynamics
  - Kinematics
  - Aero & Hydro Dynamics
  - Safety
  - Temperature

Solution:

High-Performance Computing (HPC)

Numerical analysis and simulations on high-performance systems

- Increase Capacity
- Increase Capability
- Better Flexibility
- More Cost Effective
- Leverage Volume Ecomonics

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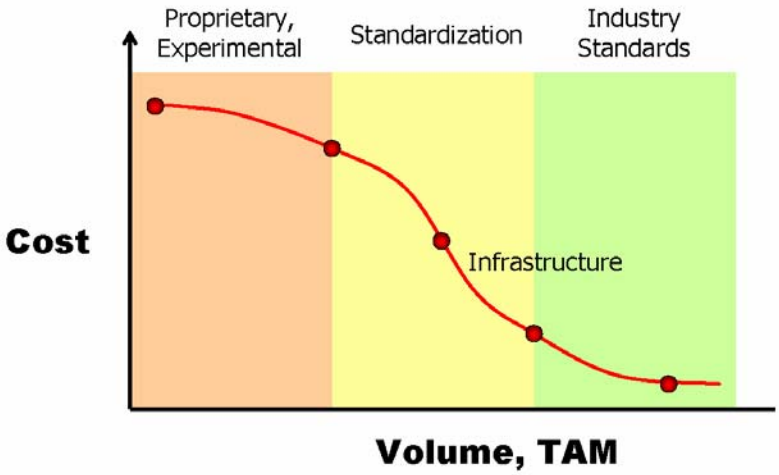
The Standardization Curve



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High-Performance Computing on **Intel® Architecture**

Some HPC History

1960s 1970s 1980s 1990s 2000s

HPC Systems	1970s	1980s	1990s	2000s
Processor	proprietary	proprietary	COTS	COTS
Memory	proprietary	proprietary	COTS	COTS
Motherboard	proprietary	proprietary	proprietary	COTS
Interconnect	proprietary	proprietary	proprietary	COTS
OS, SW Tools	proprietary	proprietary	proprietary	COTS

COTS: Commercial off the Shelf (industry standard)

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High-Performance Computing on **Intel® Architecture**

The Growing Popularity of (SMP-)Cluster Computing

2,304 Intel® Xeon™ 2.4 GHz processors power this 5.69 TFlops supercomputer at Lawrence Livermore National Labs. It rates as the fifth fastest in the world.

The number of clusters in the TOP500 has grown to nearly 20 percent, with a total of 93 systems. 56 of them are Intel Architecture based.

HPCwire

LOS ALAMOS BUILDS LARGEST INFINIBAND CLUSTER

SCIENCE AND ENGINEERING NEWS

11/28/02

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HPC is Changing

Proprietary
Expensive

→

Industry Standards
Building Blocks for
Volume Economics

Processor	→	**Intel® Architecture**
Architecture	→	**Cluster of SMP nodes**
OS	→	**Linux*, Windows***
Parallel API	→	**OpenMP*, MPI***
Performance	→	**following Moore's Law**
Costs	→	**Affordable**

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HPC Building Blocks

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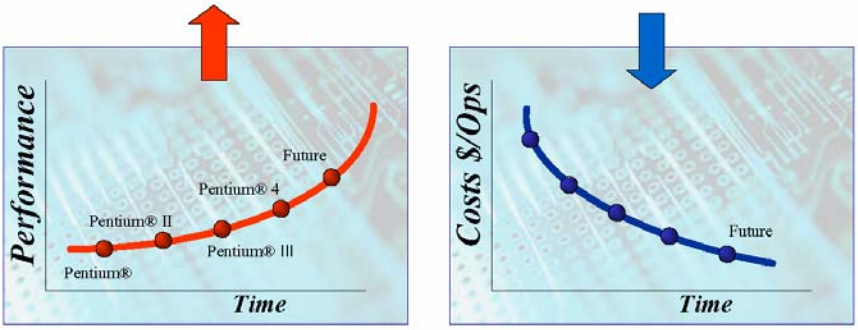
Why Intel® Architecture is so attractive



We are at an "Inflection Point" and Paradigm Shift in HPC …
Clusters of SMP nodes

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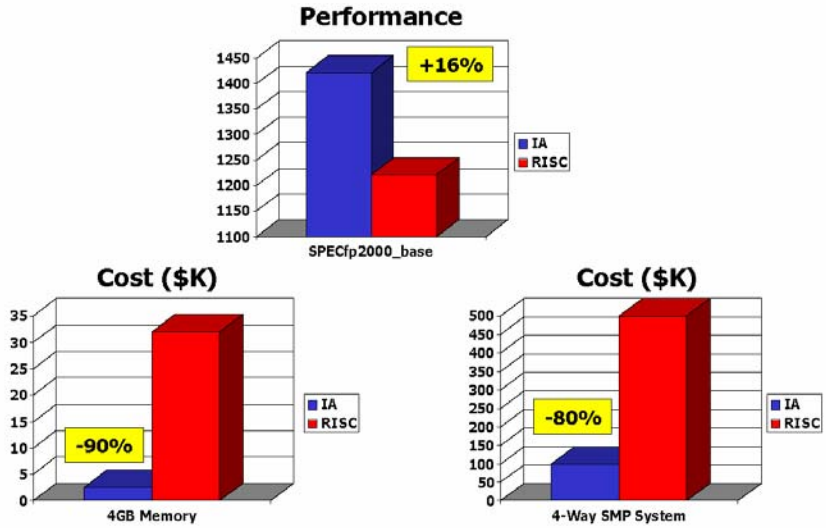
Economy of Scale



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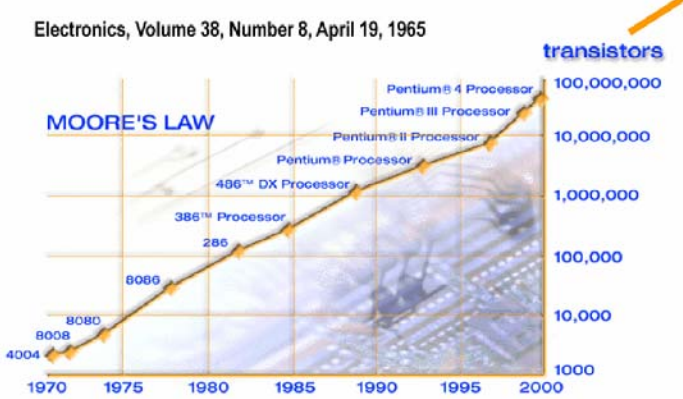
Driving The Change in Computing Economics



10GHz 1Billion Transistors ~2007 (est.)

Enabling Peta-Flop Computing

www.intel.com/research/silicon

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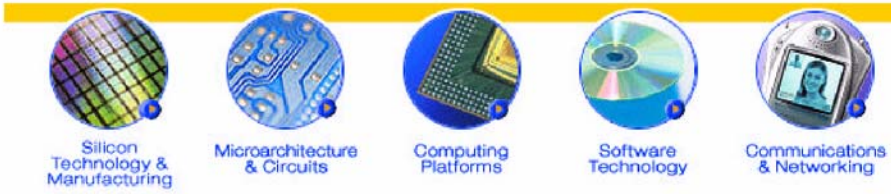
Improving Performance

Intel Research & Development

Pioneering Innovation Through Technology Leadership



- Silicon Process
- Density
- Frequency
- Manufacturing

- Micro-Architecture
- Execution Units, Caches
- Threading
- Memory Subsystem
- I/O-Subsystem
- System Architecture

- Compilers
- Libraries
- Tools
- ISVs

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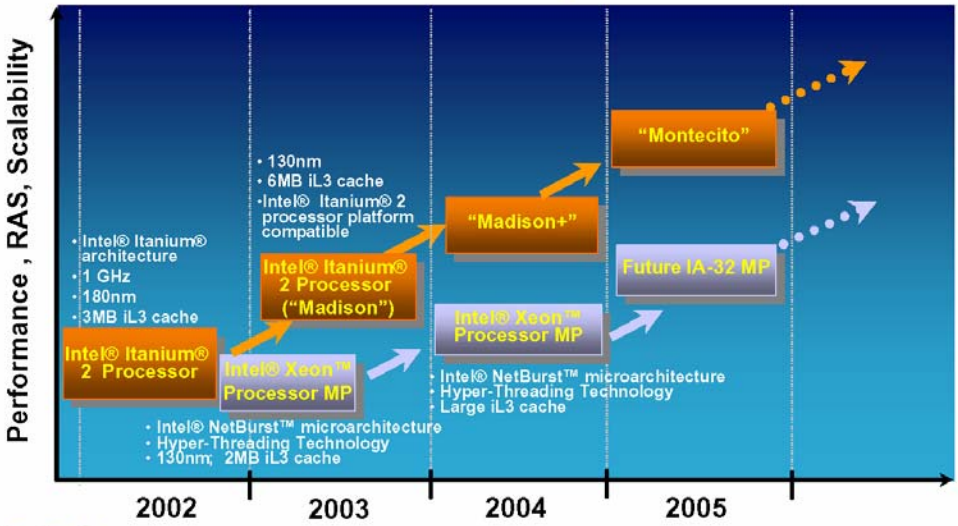
Intel® Architecture MP Server Processor Roadmap



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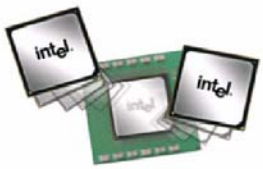
Processor Architectures

NetBurst™ Microarchitecture



Hyper-Threading Technology

EPIC Technology

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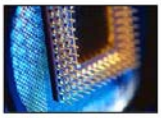
IA-32 Xeon™ Architecture



Xeon™ DP Server/Workstation Processor
3.06GHz Frequency
512KB integrated L2-Cache
533MHz Front-Side Bus
Dual-Channel DDR-266 Memory

Xeon™ MP Server Processor
2.0GHz Frequency
400MHz Front-Side Bus
2MB integrated L3-Cache
4+ way SMP Support

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Itanium® 2 Processor Performance

	Application Area	Benchmark	Results	Beats Best RISC By
Enterprise Computing	Enterprise Resource Planning	4P SAP SD[1]	600	IPF vs Alpha — *Also #1 16P* — 43%
	Supply Chain Demand Planning	4P SAP APO-DP[2]	158K	IPF vs Alpha — 15%
	On-line Transaction Processing	4P TPC-C (TPC-C)[3]	87.7	IPF vs Alpha — *Also #1 32P* — 55%
	On-line Transaction Processing	4P TPC-C ($/TPC-C)[3]	$5.03	IPF vs Alpha — 47%
	Secure Transactions	4P SPECweb99_SSL[4]	1888	IPF vs PA-RISC — *Also #1 2P & 1P* — 59%
Technical Computing	Matrix Multiplication	32P Linpack[5]	101.7	IPF vs Power 4 — 7%
	Matrix Multiplication	1P Linpack[6]	3534	IPF vs Power 4 — 22%
	Floating Point Computation	SPECfp_base2000[7]	1431	IPF vs Power 4 — 17%
	Memory Bandwidth	64P Stream Triad[8]	125K	IPF 64P vs Sun 72P — 146%

RISC comparisons based on publicly available RISC benchmark results as of 12/2/02.

1 Source www.sap.com: Itanium® 2 processor result on HP Server rx5670 using 4 Itanium® 2 processors 1GHz with 3MB L3 cache, 16GB memory, Windows Advanced Server LE 1.2, SAP rev 4.6 C, 2Q2_Server Enterprise Edition 64bit. Alpha result of 420 on HP AlphaServer ES45 using 4 Alpha EV68CB 1GHz, 42 GB memory.

2 Source www.sap.com: Itanium® 2 processor result on a HP Server rx5670 using 4 Itanium® 2 processors 1GHz with 3MB L3 cache, 32GB memory, Windows Advanced Server LE 1.2, SQL Server 2000. Alpha result of 1963.2 on HP AlphaServer ES45 using 4 Alpha 21264C EV6.8CB 1.25 GHz, 32 GB memory.

3 HP server rx5670, 87,741 tpmC at $5.03/tpmC, with 4 Itanium® 2 processors at 1GHz with 3MB L3 cache, Microsoft Windows .NET Advanced Server, Microsoft SQL Server 2000 Enterprise Edition 64-bit, published 12/16/03. 1 HP AlphaServer ES45 Model 68/1250, 50,370tpmC at $9.44/tpmC with 4 HP Alpha chip 2 1250MHz at 1250 MHz with 16MB of L2 cache, Tru64* Unix V5, Sybase Adaptive Server Enterprise v12.5, 32 GB RAM, available 9/27/02.

4 Source: www.spec.org: Itanium® 2 processor result on HP Server rx5670 using 4 Itanium® 2 processors 1GHz with 3MB L3 cache, 16GB memory, HP-UX, availability Q4'02. PA-RISC result on HP Server rp5470 using 4 PA-8700+ processors 875MHz, 16GB memory, HP-UX, availability Q4'02.

5 Source: www.netlib.org, Itanium® 2 processor result on NEC Server TX7/i8510 using 32 Itanium® 2 processors 1GHz with 3MB L3 cache, 128GB memory, Linux OS. Power 4 result of 95.2 on IBM P690 using 32 Power 4 1300MHz.

6 Source: www.netlib.org: Itanium® 2 processor result on HP Server rx5670 using one Itanium® 2 processor 1GHz with 3MB L3 cache, 24GB memory, HP UX. Power 4 result of 2894 on IBM eServer P690 using one Power 4 1GHz.

7 Source www.spec.org: Itanium® 2 processor result on HP Server rx5670 using Itanium® 2 processor 1GHz with 3MB L3 cache, 8GB memory, RH Linux 2.1, HW availability Q4'02. Power 4 result of 1221 on IBM eServer P690 Model 681M 32 using Power 4+ 1450MHz, 8GB, availability 1Q'03.

8 SGI Altix* 3000 result of 124,601 MB/s using 64 Intel® Itanium® 2 processors, 16GB memory, Linux, reported 1/1/03. 1 Sun Fire 15K result of 50,724 MB/s using 72 UltraSPARC* III Cu at 1.05GHz, 576GB memory, Solaris 9, reported 5/1/02.

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, reference www.intel.com/procs/perf/limits.htm or call (U.S.) 1-800-628-8686 or 1-916-356-3104

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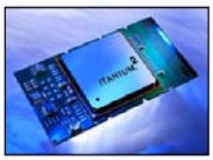
Madison**



**codename

Next-Generation Itanium® Architecture Processor
130nm Process
410M Transistors
Up to 1.5GHz Frequency
6MB integrated L3-Cache
Pin-Compatible to Itanium® 2 Processor
Same Thermal Envelope
Low-Voltage Version (Deerfield)**

~1.3-1.5x faster than Itanium® 2

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High-Performance Computing on Intel® Architecture
Itanium® Architecture Systems
High-end Itanium® 2-based systems ...
>2X more than Itanium !
HITACHI
IBM
Bull
UNISYS
NEC
sgi
2P WS
Shipping
DP/1U
2H2003
2P/2U
4P
Shipping
4P/4U
2P/ 2
Shipping/ 2Q2003
4P/8P/16P
1H2003
16P
Shipping
32P
Shipping
64/512P
Shipping/2003
(not drawn to scale)
*Other brands and names are the property of their respective owners
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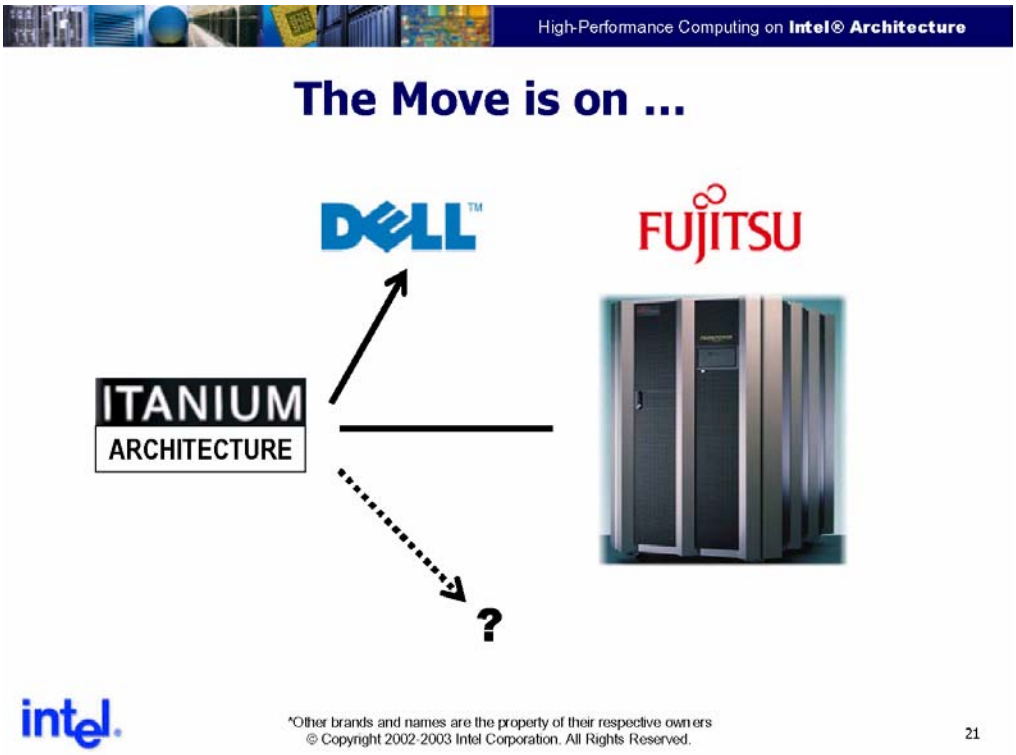
High-Performance Computing on Intel® Architecture
The Move is on ...
DELL
FUJITSU
ITANIUM
ARCHITECTURE
?
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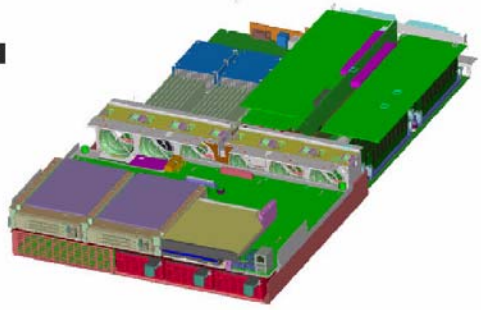
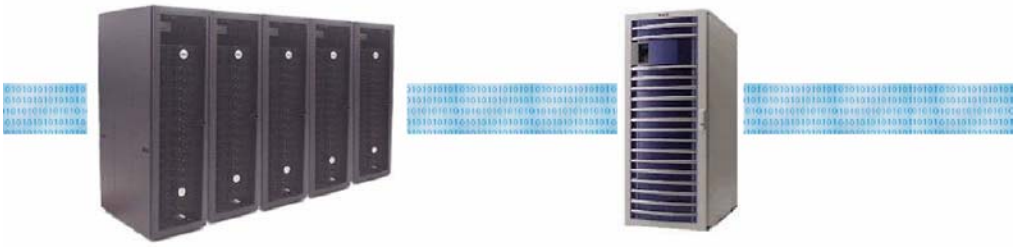
Itanium® 2 DP, 2u, E8870 System

"Tiger-2" platform (SR870BH
Q2'03 target availability
Madison/Montecito ready
1-2 CPUs
8 DIMM slots (16GB)
3 PCI-X slots
2GbE on board
2H2003



Performance Scaling



Scale-Out
(Cluster)

Scale-Up
(SMP, ccNUMA)

SMP Nodes

8u (1-8 CPUs)	Scalable
4u (1-4 CPUs)	Expandable
2u (1-2 CPUs)	Dense
1u (1-2 CPUs)	Dense
Blades	Ultra-Dense

64-512P

32P

16P

Do more, better and faster at lower costs.

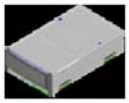
Increase Capacity and Capability

Scaling Out and Scaling Up

→ Scaling Right

DP/1U

DP/2U



4P/4U

4P/8P/16P

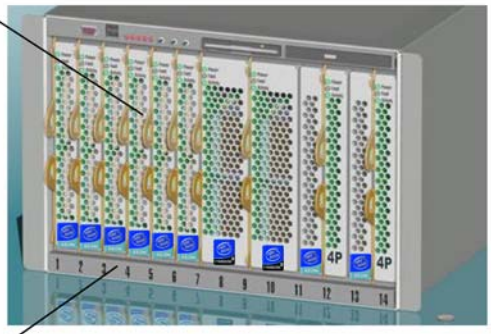
High-Performance Computing on **Intel® Architecture**

Blade Clusters – The Next Wave?

- **Range of compute performance available**
  - From initial release through first 9 months
- **2-way Intel® Xeon™ processor blade (1 slot)**
- **4-way Xeon processor blade (2 slots)**
- **2-way Itanium™ 2 processor blade (2 slots)**
- **Dual, redundant connectivity to backplane for LAN and storage networks**
  - 1 Gb Ethernet
  - 2 Gb Fiber Channel

- **7U Chassis**
  - 28" Depth
- **14 Compute Blade Slots**
- **Dual-Dual Star Backplane Topology**
- **Dual, Redundant Power Supply**
- **Dual, Redundant Blowers**

Product concept:
compute blade and chassis



Enabling
1 TFLOP in one Rack.

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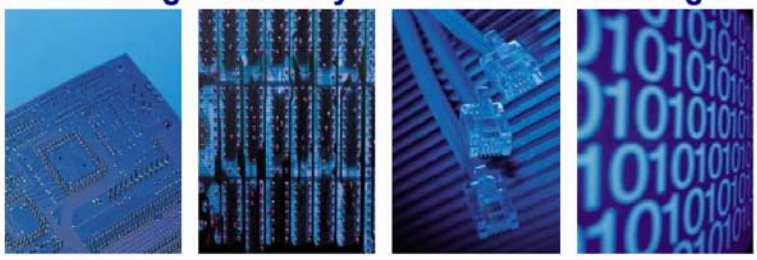
High-Performance Computing on **Intel® Architecture**

Modular Scaleable Computing

Processing **Memory** **I/O** **Storage**



Flexible and Balanced Solution
using Industry Standards

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Interconnects

- 100Mbit/s, 1000Mbit/s Ethernet
- 10Gbit/s Ethernet
- GigaNet*
- SCI*
- Myrinet*
- QsNET*
- Infiniband*
- Crossbar (proprietary)
- [cc]NUMA (proprietary)

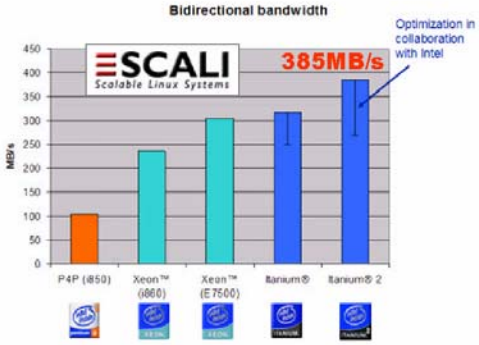
PCI/PCI-X based

future

intel.

Interconnects

QUADRICS
1.2GB/s
multi-rail
on Itanium® 2



over 800 Mbytes/sec bandwidth and 8.7 microsecond latency

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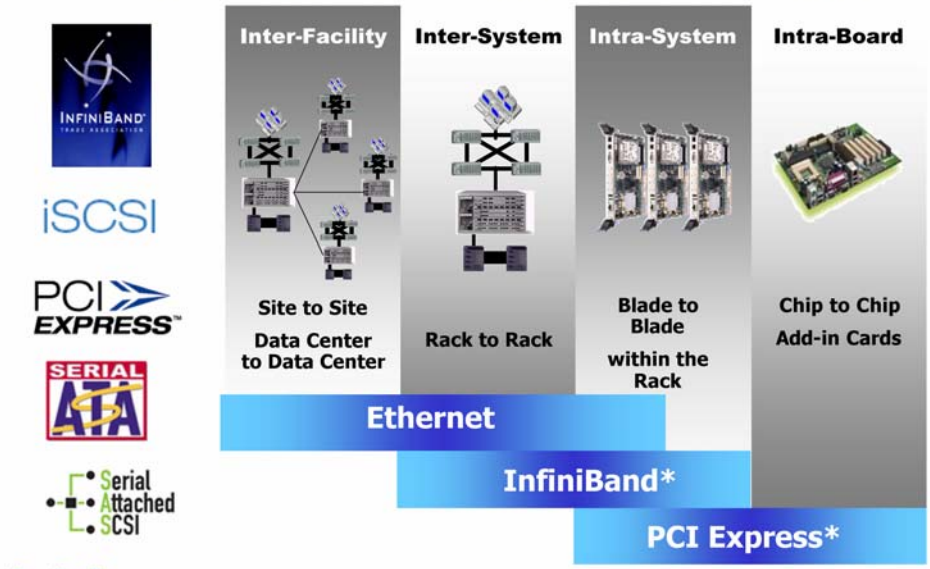
Evolving Interconnects & Storage



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Software Development Tools

SW Products

Compilers

Performance Libraries

VTune™ Performance Analyzer

Intel® Threading Tools

www.intel.com/products/software

Developer Services

www.intel.com/ids

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Summary

- The Economics of High-Performance Computing have changed.
- High-Performance Computing solutions must track Moore's law to be viable.
- Intel is playing a key role in accelerating HPC solutions for science, engineering and business with open commercial off the shelf technology leadership.

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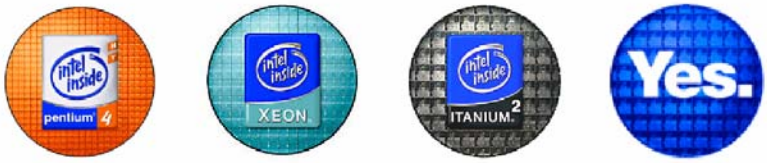
Technology Leadership



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